

ON SOME SPECIMENS OF CHIASTOLITE FROM BIMBOWRIE, SOUTH AUSTRALIA.

By C. ANDERSON, M.A., B.Sc., Mineralogist.

(Plate xlvii.)

THE Trustees of the Australian Museum have recently acquired from Mr. G. R. Howden, by donation and purchase, some exceptionally good specimens of chiastolite. In addition to those in the Museum, I have been enabled, through the courtesy of Mr. E. F. Pittman, Government Geologist, and Mr. G. W. Card, Curator of the Mining and Geological Museum, to examine some fine specimens in the Survey collection. Mr. W. S. Dun, Palæontologist to the Survey, was also kind enough to lend me some specimens which he has in his possession. All the minerals examined came from the same locality, Mt. Howden, ten miles north of Bimbowrie, South Australia. The crystals are distinguished by large size, they shew the characteristic markings very distinctly, and some exhibit features which, so far as I know, have not hitherto been described.

Chiastolite is a variety of andalusite, and is only distinguished from it by the constant occurrence of carbonaceous or clay-slate inclusions, disposed in the form of a cross. Andalusite and chiastolite are characteristic of the metamorphic schists, and are usually found in the contact zones of clay slates, near granites, syenites, and diorites. The crystallographic system is orthorhombic, the forms being very simple, usually shewing only (110) and (001). The pattern of the dark inclusions seen on a cross section varies considerably, even in different segments of the same crystal, but two chief types are apparent—(a) The crystal has a dark rhomb in the centre, the outlines of which are parallel with the crystal boundaries, and, from the angles of this rhomb, dark laminae pass to the prism angles of the crystal (*nucle tetragrammé* of Haüy); (b) further the angles of the prism may be occupied by four dark rhombs, corresponding in form with that in the centre (*macle pentarhombique* of Haüy.)

According to Mr. Howden, the Bimbowrie mineral occurs either embedded in argillaceous schist, or as rolled pebbles, along with quartz, jasper, aventurine, etc. Towards the surface, where atmospheric influences are at work, the crystals are fairly easy of extraction, and all the more perfect specimens obtained were

weathered out. Mr. Howden states that embedded crystals occur with the long axis parallel to the foliation. The crystals are columnar in habit, elongated in the direction of the vertical axis. Some specimens reach a length of five to six inches, and one, (Pl. *xlvii.*, fig. 1), has a diameter of about two inches. None show well defined crystal outlines, the edges being more or less rounded. When complete the crystals taper to either end, the relation of length to breadth being about 4 : 1. They have a brownish crust, and the surface is spangled with flakes of mica. The two cleavages parallel to the prism faces are usually followed by lines of inclusions. The specimens are altered in a greater or less degree, hence the physical characters vary considerably. The hardness is about 3 to 4, and the specific gravity, determined on the freshest material obtainable, selected as free as possible from inclusions, was found to be 2.99. The fracture is uneven. The colour of a cut crystal varies, grey predominating, but some are reddish brown, and some have a pinkish tinge. Slightly translucent. Difficultly fusible on the edges before the blowpipe.

Professor T. W. E. David, of Sydney University, and Mr. H. Stanley Jevons, the University Lecturer in Mineralogy, have made a detailed examination of sections under the microscope, and have obtained some interesting results, which Professor David has kindly communicated to me. "With a view to ascertain whether these chiasmolites are normal as regards optical properties, and whether they are really single crystals and not twinned forms, a section was cut at an angle of 48° , measured from the vertical axis, and in a direction parallel to the macro-diagonal axis, so that the plane in which the section was cut made an angle of 42° with the basal plane. It was found that this section cut one of the optic axes at right angles, which is evidence in favour of the acute bisectrix being parallel to the vertical axis of the crystal. This fact having been established, a section of the crystal cut at right angles to the vertical axis was examined, and the optic sign was found to be negative. The optic axial plane was found to lie in a plane about normal to that of the macropinacoid. The optic axial plane, however, does not lie parallel to the dark plane, crossing the crystal diagonally and showing the morphological direction for the plane of symmetry parallel to the brachypinacoid, but makes an angle of about 12° with it. From this it is obvious that this morphological plane, indicated by the black lamina, is not normal to the macropinacoid, but, in the crystal examined, makes angles of about 102° and 78° with it. This distortion of the morphological plane, which should be the plane of symmetry parallel to the brachypinacoid, is, however, not accompanied by a similar distortion of the direction of the planes of prismatic cleavage. The optic axial plane, being normal to the macropinacoid, bisects the obtuse angles of the prismatic cleavage. Mr. Jevons suggests that perhaps very minute, numerous, parallel,

fault-, or gliding-planes¹ may have led to the distortion of the *morphological* plane, which should be parallel to 010. The parallelism of the optic axial plane, in all the quadrants of the crystal, proves that the crystal is optically continuous, and not twinned."

From the arrangement of the inclusions the Bimbowrie mineral may be described as a modified *maclé pentarhombique*. Instead of having a solid dark rhomb in the centre, the core is usually of light-coloured material, and is surrounded by four dark lines, forming a rectangle or lozenge, according to the direction of cutting. Moreover, the inclusions appear on the prism angles as roughly triangular areas and not as rhombs. In some cases the central rhomb is very small or absent, and, as a rule, the angular patches of inclusions are well developed; occasionally, as in Fig. 2, reaching almost to the centre.

A few typical specimens have been selected for particular description; some are the property of the Trustees, the others belong to the Geological Survey collection.

Fig. 1.—On the cross section this specimen measures $2\frac{1}{4}$ inches, and is undoubtedly one of the finest chialstolites discovered. On the polished surface the colour is brownish-red, which unfortunately prevents the photograph from doing justice to the mineral. The triangular areas are dark in colour, but the rest of the inclusions are mostly reddish-brown, and are possibly oxide of iron. The cleavages, crossing at approximately 90° , are indicated by lines of inclusions, parallel to the prism faces.

Fig. 2 is a photograph of one of the Geological Survey's specimens, and represents a typical Bimbowrie chialstolite. Its greatest breadth is $1\frac{1}{2}$ inches. The central rhomb and the dark patches are well defined, the latter being differentiated into two areas, the inner being darker in colour, while the outer is greyish. The latter portion is very evidently clay-slate, and externally shews the schistosity clearly. These included wedges of clay-slate can be distinguished without reference to the cross section by the presence of this schistosity, and by the absence of mica in the crust.

Fig. 3 was originally five inches long, but was cut into seven segments, in order to see how the inclusions varied in different parts of the crystal. The result was not conclusive, but seemed to shew that the central rhomb increased in size from the middle towards either end. Before cutting, a depression was noticeable running from end to end on either side. These depressions are occupied by soft and friable clay-slate, and have evidently resulted

¹ Rosenbush—*Micr. Phys. of the Rock-making Minerals*, trans. Iddings, 4th edit., 1900, p. 196, states that such gliding-planes exist in andalusite parallel to 100, and give rise to mechanical deformation of the crystal. Such gliding planes would account for the mechanical deformation of the chialstolite crystals described in this paper.

from weathering. Only two of the clay-slate wedges are affected in this way. The central inclusion figure is very small in this specimen.

Figs. 4 and 5.—Here the weathering effect is still more pronounced, the transverse section resembling a penetration twin. That the form is not the effect of twinning is apparent, since it differs in no respect from an ordinary crystal, save that the included wedges of clay-slate have been removed. Fig. 5 gives a longitudinal view, from which it is seen that the surface is homogeneous, presenting no clay-slate wedges, yet the transverse section shews the remains of the dark triangular areas, corresponding no doubt to the inner areas of inclusions in fig. 2. Fig. 5 also shews a peculiar feature which I have not seen alluded to in any description of chialstolite. Nine specimens shew this structure out of thirty-eight examined, hence it is a well-marked feature of the Bimbowrie mineral. In all cases where the removal of the clay-slate has proceeded to a considerable extent, this phenomenon occurs, and the appearance in all cases is strictly analogous. The cross has two longer and two shorter arms, the former alone shewing this peculiarity, which consists of a series of grooves, alternating with ridges, which proceed from the junction with the shorter arms to the boundary of the crystal, and these grooves and ridges are always curved in opposite directions, as shewn in fig. 5, where those on the right side have the concavity downwards, while those on the left have the concavity upwards. In most cases another peculiarity is noticeable, namely, the longer arms are slightly bent in opposite directions, as if a shearing stress had acted on the crystal in a direction perpendicular to the vertical axis. Thus, in fig. 5, the right side is bent away from the observer, the left side towards him. This deformation is well-marked whenever the grooving is most apparent. In one specimen the arms are nearly straight and the grooving is but slightly developed, hence it may be that the two phenomena are related. In two cases the clay-slate wedge has persisted in alternate reëntrant angles, and, assuming the action of the stress referred to, the phenomenon in these two cases may be not inaptly compared to "crag and tail" of geologists, the wedge being scooped out on the side exposed to this hypothetical force, while it still remains on the other.

Fig. 6 furnishes a notable example of parallel growth. The foreign matter occupies roughly parallel positions in the two individuals, while one patch of inclusions is common to both. The included areas are of uniform dark color, and shew no differentiation such as is apparent in fig. 2, and the crust is homogeneous.

Rohrbach² explains the peculiar structure of chialstolite crystals by supposing the growth to proceed unequally, the crystal

² Rohrbach—Zeitschr. Deuts. Geol. Ges., 1887, 39, 635.

increasing more rapidly in the direction of the prism faces than towards the angles. The structure of many of the Bimbowrie specimens is such as to favour this view. According to Lehmann crystals forming in a solution grow most rapidly on the edges, as diffusion currents promote more rapid growth of the angles. But chialstolite is formed by the agency of metamorphism in a presumably solid rock, permeated, no doubt, by heated water and gases, and quite different laws of crystal growth may prevail in such cases. Referring to fig. 2, where the foreign matter forms nearly one half of the entire mass, it seems scarcely admissible, considering the large amount of inert matter, to speak of the crystallising force "constraining" the inclusions to assume a certain regular position. But, by irregular growth, reëntrant angles are formed, and in these a considerable amount of clay-slate is caught up, some being incorporated in the body of the crystal, but the bulk being more nearly related to the containing rock mass. Further metamorphic action may render the union of mineral and "inclusion" more intimate, but that each is semi-independent is apparent from the result of weathering seen in fig. 4.

Prof. Liversidge³ states that chialstolite occurs in granite rock at Arnprior, Boro, near Goulburn; in small crystals in slate near Modbury, Shoalhaven; and near Tumut, in micaceous slate or schist. Mr. E. F. Pittman has found it occurring as small crystals in slate, at the Euriowie Tin Field, Barrier District.

Chialstolite slates, containing small crystals of that mineral, are also known from Queensland, Victoria, and Tasmania. It is interesting to note that the Geological Survey of New South Wales possesses a microscopic section of an aboriginal stone axe, from Strathbogie, Scone, Co. Gough, New South Wales, containing small crystals of chialstolite, some of them very well formed.⁴

³ Liversidge—Min. New South Wales, 1888.

⁴ David—Proc. Linn. Soc. N.S.W., (2), ii., 4, 1887, p. 1084.